DIGITAL SIMULATION OF EIGHT BUS SYSTEM USING TCTC & STATCOM

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ABSTRACT

This paper deals with power quality improvement by using TCTC & STATCOM. When the reactive power of the load is changing continuously, a suitable fast response compensator is needed. STATCOM and TCTC (Thyristor controlled tap changer) are two such compensators belonging to FACTS devices. They are used in this work. Models for the STATCOM &TCTC (Thyristor tap changer) are developed using MATLAB simulink. Smooth reactive power control is achieved by varying the firing angle of TCTC system. The simulation results of eight bus system with STATCOM & TCTC are presented.

Key words: Reactive power, STATCOM, Thyristor controlled Tap changer.

I. INTRODUCTION

The possibility of controlling power flow in electric system without any rescheduling and topological changes can improve the power system performances [1]. It has been proved that, instead of building new transmission lines, an efficient usage of the existing line to their thermal limit is possible [1-3].

FACTS, which are power electronic based devices can change parameters like impedance, voltage and phase angle. Therefore they have the ability to control power flow pattern and enhance the usable capacity of the existing lines. The important feature of FACTS is that they can vary the parameters rapidly and continuously, which will allow a desirable control of the system operation.

FACTS devices are good to improve the power system efficiency, improve power factor and reduced in harmonics. Reactive power is used to control the voltage levels on the transmission system to improve the efficiency of the system.

TCPAR can alter the phase angle to control the power flow pattern. This component can benefit the system operation in aspects like voltage control, power factor improvement and reactive power compensation [4-6]

Next to the generating units, transformers consist the second family major power transmission system apparatus. In addition to increasing and decreasing nominal voltages, many transformers are equipped with tap changers to realize a limited range of voltage control. This tap control can be carried out manually or automatically. Tap changers may be provided on one or two transformer windings as well as on autotransformer.

This paper deals with the effect of thyristor tap changer and STATCOM in a power system and how well they improve the system performance on the basis of power factor and reactive power control.

A continuously controllable thyristor tap changer can give continuous control with varying degree of circuit complexity [7].

The static synchronous compensator (or) STATCOM is a shunt connected reactive power compensation device. It is capable of generating or absorbing reactive power.

The above literature does not deal with simulation of eight bus system with TCTC and STATCOM. An attempt is made in the present work to study the power flow in eight bus system employing TCTC and STATCOM.

II. THYRISTOR CONTROLLED TAP CHANGER SYSTEM

The basic power circuit scheme of a thyristor tap changer with RL load is shown in the below diagram. This arrangement gives continuous voltage magnitude control by initiating the onset of the thyristor valve condition.

Here on load tap changing transformer are used to control correct voltage profile on an hourly or daily basis to accommodate load variations.

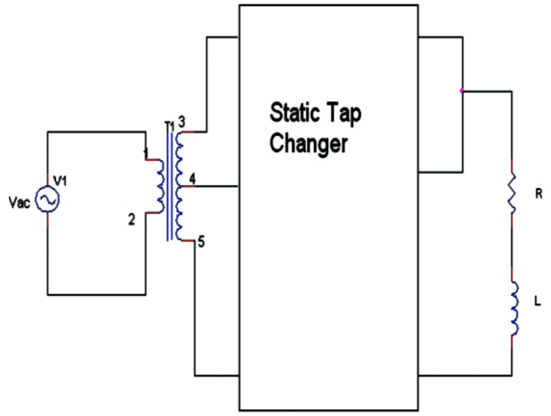

Fig. 1. Thyristor Tap Changer system

It shows that at $\alpha = 0$, in the case of resistive load, the current crosses zero and thus the previously conducting valve turns off, valve sw_1, turns on to switch the load to the lower tap. At $\alpha = \alpha_2$, valve sw_2 is gated on, which commutates the current from the conducting thyristor valve sw_1, by forcing a negative anode to cathode voltage across it and connecting the output to the upper tap voltage V_2. This valve sw_2 continues conducting until the next current zero is reached, where the previous gating sequence continues. On inspection of this waveform, by delaying the turn on of sw_2 from zero to any voltage between V_2 to V_1 can be attained.

Fourier analysis of the output voltage waveform for idealized continuously controlled thyristor tap changer, operating between voltages V_1 and V_2 with resistive load and delay angle α with respect to zero crossing of voltage, can be yielding the expression for fundamental component.

$$V = \sqrt{a_1^2 + b_1^2}. \qquad [1]$$

$$\psi = \tan^{-1} (a_1/b_1) \qquad [2]$$

Where

V = amplitude of the fundamental

ψ = phase angle of the fundamental with respect to unregulated voltage.

$$a_1 = (V_2 - V_1/2\,\pi)\,(\cos 2\,\alpha - 1)$$

$$b_1 = V_1 + (V_2 + V_1/*\,\pi)\,(*\,\pi - \alpha + \sin^2\alpha/2\,\pi)$$

The variation of amplitude V and ψ of the fundamental voltage V with delay angle α for an assumed ± 10% regulation range ($V_1 = 0.9$ and $V_2 = 1.1$ on)

III. STATCOM

A. Emerging FACTS controller

STATCOM is a shunt connected reactive power compensation device. It is capable of generating & absorbing the reactive power. It can be improve the power system in the areas are

- Dynamic voltage control in transmission and distribution.
- Power oscillation damping in transmission system.
- Transient stability.
- Voltage flicker control.
- Control not only reactive power but also active power in the connected lines.

B. Principle of operation

The power circuit diagram for STATCOM as shown in the below diagram. It is a controlled reactive power source. It provides the reactive power generation and absorption by means of electronic process of the voltage and current waveforms in a voltage source.

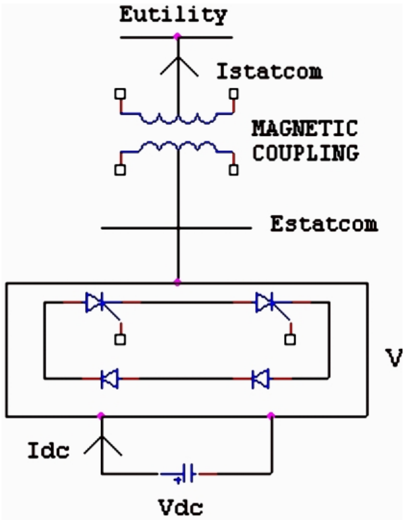

Fig. 2. Power circuit diagram

A single line diagram of STATCOM is shown in the below diagram, where Vsc is connected to the utility bus through the magnetic coupling transformer. It is a compact design, small foot print, low noise and low

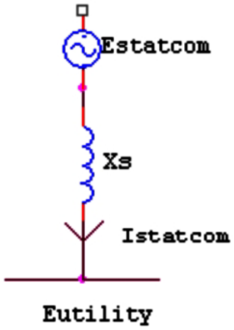

Fig. 3. Line diagram of STATCOM

magnetic impact. The exchange of reactive power between the converter and *AC* system can be controlled by varying the three phase output voltage, E_s of the converter.

If the amplitude of the output voltage is increased above that the utility bus voltage, then the current flows through the reactance from the converter to the ac system and the converter act as a capacitance and generates reactive power for the *ac* system.

If the amplitude of the output voltage is decreased below the utility bus voltage, then the current flows through the reactance from the ac system to the converter and the converter act as inductance and it absorbs the reactive power for the ac system.

If the output voltage equals the ac system, then the reactive power exchange becomes zero. On that condition STATCOM is to be in a floating state.

STATCOM controller provides voltage support by generating or absorbing reactive power at the point of common coupling without the need of large external reactors or capacitor banks.

IV. SIMULATION RESULTS

The simulation is done by using mat lab simulink and the results are presented. Circuit model of eight bus system is shown in Fig 3 Each line is modeled by its series Impedance. The load at the load buses is represented by the combination of *R* and *L*. The shunt capacitances of the line are neglected. Circuit model of eight bus system without controller is shown in Fig 4. The Voltage across Bus 3 without controller is shown in Fig 5. The RMS voltages across Bus 3 without controller are shown in Fig 6. The Real and Reactive power at bus 1 without controller are shown in Fig 7. The Real and reactive power in bus 6 without controller are shown in Fig 8. The Real and Reactive power I bus 7 without controller as shown in Fig 9. The circuit with controller is shown in Fig 10. The Voltage across Bus 3 with controller is shown in Fig 11. The RMS voltages across Bus 3 with controller are shown in Fig 12. The Real and Reactive power at bus 1 with controller are shown in Fig 13. The Real and reactive power in bus 6 with controller are shown in Fig 14. The Real and Reactive power I bus 7 with controller as shown in Fig 15. The TCTC system is modeled as a subsystem. The circuit for the subsystem is shown in Fig 16. The circuit model for STATCOM as shown in Fig 17. The summary of Real and Reactive powers with and without controller is

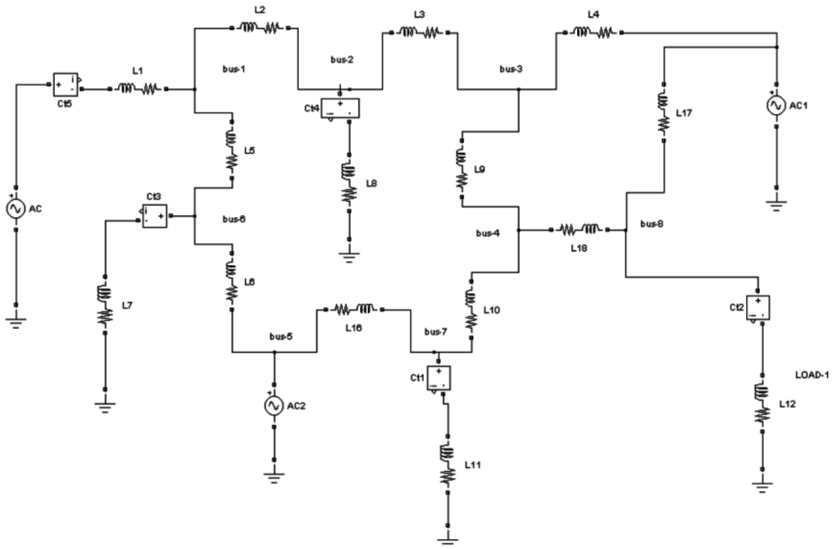

Fig. 4: Model of 8 Bus system

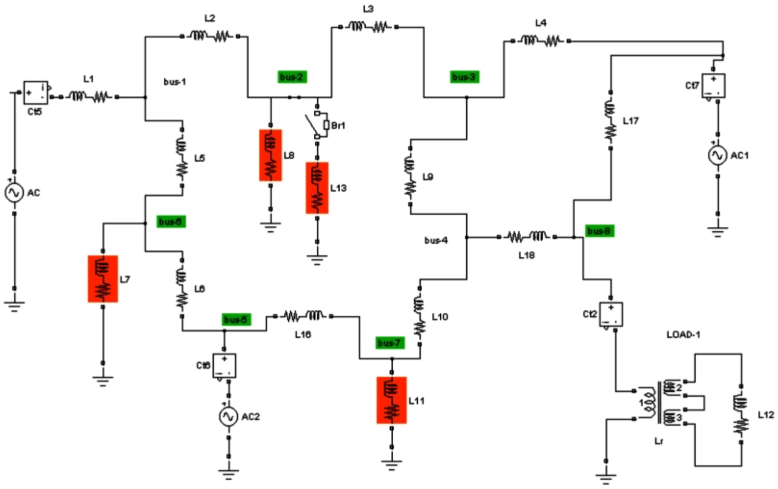

Fig. 5: Circuit diagram without tctc and statcom

given in Table 1. It can be seen that the reactive power is increased at buses 6 and 8 due to the presence of TCTC. The increase in the Reactive power is due to the increased voltage difference between sending end and receiving end.

The technical specifications of fig 1 are as follows

$V_1 = 5\text{KV}\ V2 = 2\ \text{KV}\ V_3 = 3\ \text{KV}$

$R = 150\ \Omega\ L = 50\ \text{mH}$

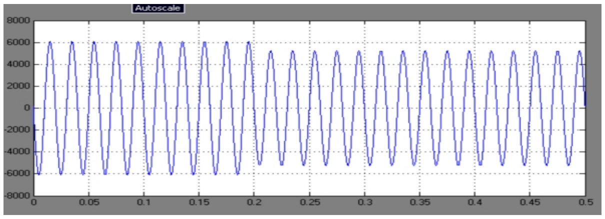

Fig. 6: Voltage across bus-3

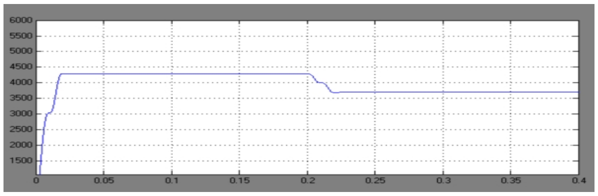

Fig. 7: RMS Voltage across bus-3

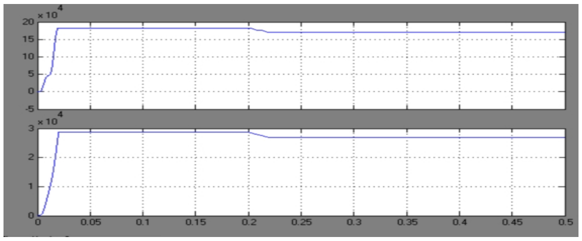

Fig. 8: Real and reactive power in bus-1

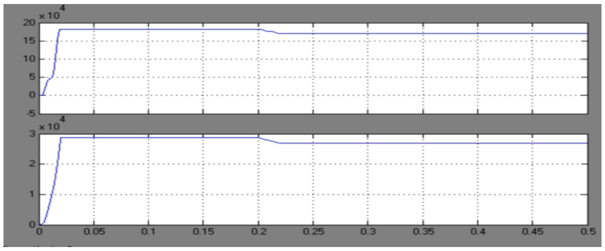

Fig. 9: Real and reactive power in bus-6

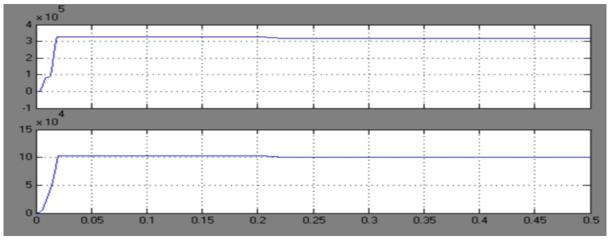

Fig. 10: Real and reactive power in bus-7

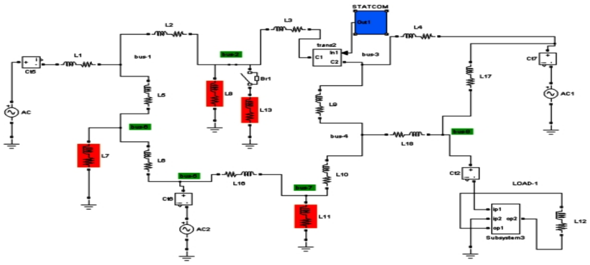

Fig. 11: Circuit diagram with tctc and statcom

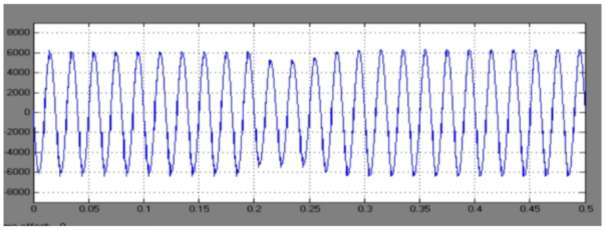

Fig. 12: Voltage across bus-3

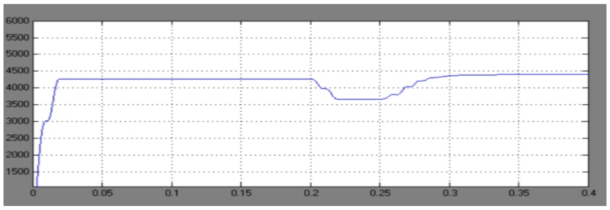

Fig. 13: RMS Voltage across bus-3

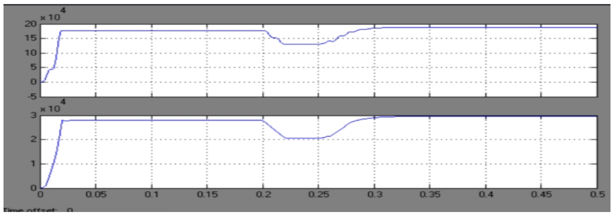

Fig. 14: Real and reactive power in bus-1

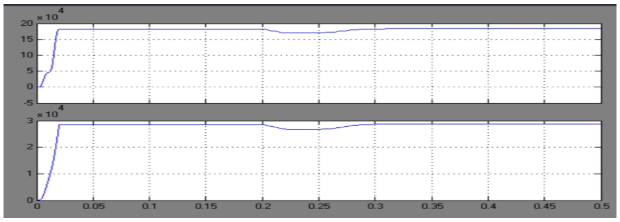

Fig. 15: Real and reactive power in bus-6

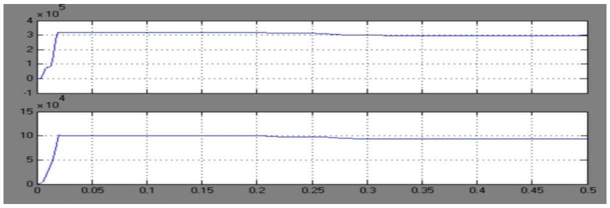

Fig. 16: Real and reactive power in bus-7

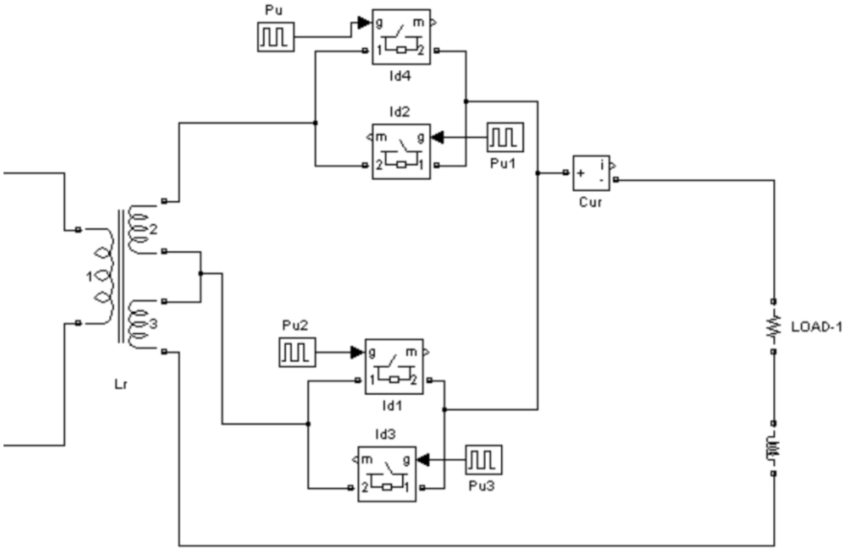

Fig. 17: Transformer tap changing system

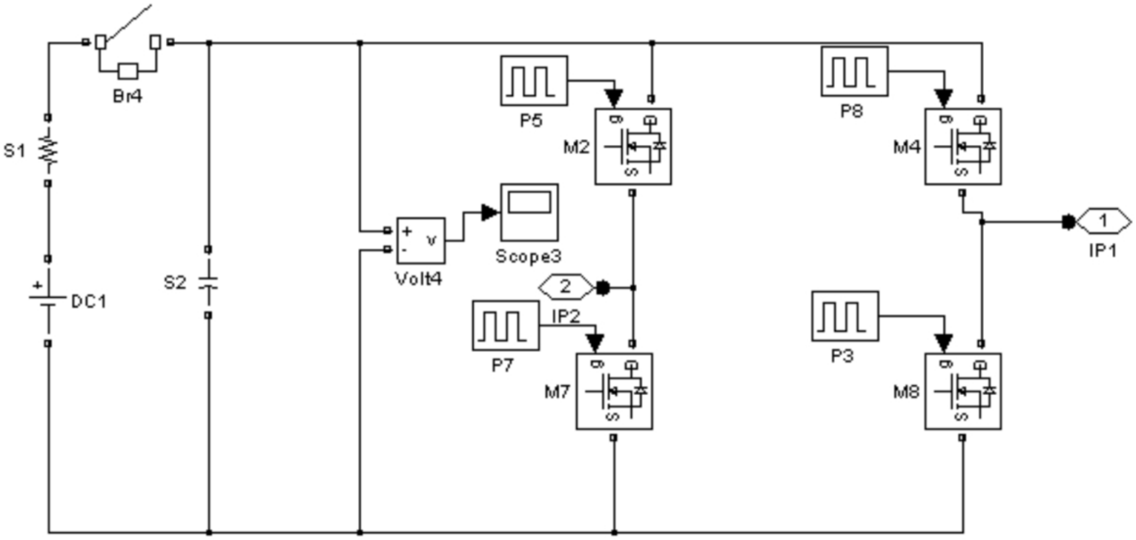

Fig. 18: Statcom model

TABEL I. Summary of Real and Reactive Powers

BUS NO	Real Power (MW) Without Controller	Real Power (MW) With Controller	Reactive Power (MVAR) Without Controller	Reactive Power (MVAR) With Controller
BUS-1	0.301	0.222	0.023	0.0795,
BUS-2	0.133	0.187	0.021	0.0296
BUS-3	0.500	0.747	0.327	1.19
BUS-4	0.311	0.364	0.093	0.298
BUS-5	0.505	0.518	0.221	0.261
BUS-6	0.171	0.183	0.026	0.0288
BUS-7	0.320	0.298	0.100	0.0936
BUS-8	0.134	0.187	0.015	0.089

V. CONCLUSION

TCTC and STATCOM are analyzed and the circuit model for the system is developed using the blocks available in MATLAB. Eight bus system with TCTC and STATCOM are simulated and the results are presented. Reactive power increases with the increase in firing angle of TCTC. Thus the variation of reactive power is possible with the variation in the firing angle. The simulation results closely agree with the theoretical results. The static on load tap changer system has advantages like spark free operation, reduced maintenance and improved response. Therefore the static tap changer system is a viable alternative to the existing on load tap changer system. This system suffers from the drawback of the output harmonics due to the chopped voltage across the load. The scope of the present work is the digital simulation of TCTC and STATCOM using mat lab. The hardware implementation is yet to be done.

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